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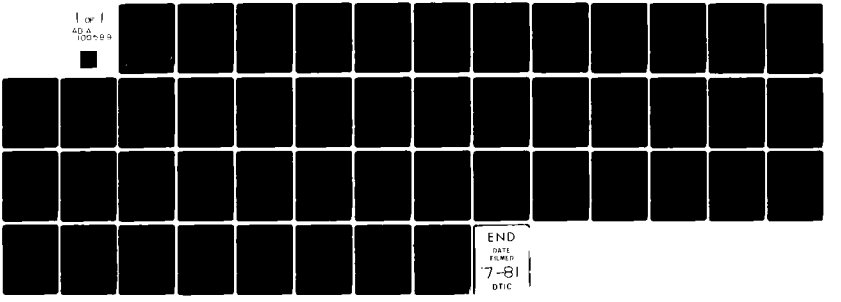

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INTRODUCTION

Intermittent concern, variously expressed, with the relationship of individual physiology to social situations has been with social psychology at least since that field borrowed from biology the concept of homeostasis. The newer balance theories in the social sciences share with earlier views the central notion that disruption of the system produces effects on the social, psychological, and physiological levels and that the system will tend to attempt to reduce that tension by re-establishing balance (homeostasis). We would like to present some of the relationships and considerations in this chapter that have been made between a basic social process and endocrine measures which have been related to homeostasis and behavior.

Sociology is concerned in part with the ways in which group structure influences individual behavior. Status is viewed as one of the basic structural processes of social behavior in humans and other animals, although expressed differently in different species. The importance of status as a concept for social behavior would parallel the importance of the concept of the utilization of glucose for biochemistry. Although not generally recognized by persons with training in "psychological" areas, concepts such as status are the heart of investigation for social scientists involved in the study of interactional processes. We would like to examine some aspects of status as an example of a basic social behavior and present some of the correlations which have been made between status behaviors and endocrine behaviors.

We are presenting this system of organization for heuristic reasons: It permits a juxtaposition of two stances of inquiry, each of which seems relevant to psychiatry and which can be made relevant to each other. However, utilizing such a system for some purposes does not preclude recognizing the value of other

ways of inquiring into the relationships of physiology to behavior.

The physiological responses with which we will be concerned in relation to status behaviors will emphasize hormonal patterns involving the adrenal cortical steroids, adrenal medullary hormones, and gonadal hormones, and brain neuroregulators. Each of these endocrine or neuroregulatory systems has, at some time, been considered as one of the body's systems of homeostatic mechanisms, and each of the systems is activated or depressed under differing stimulus conditions, remains in effect for differing lengths of time, and influences other systems of response differentially. Individual variation is great, and, the data to date can in no way be applied as an explanation to any given single event. The knowledge that has been accumulated represents promise, but the needs for further information in the systems directly mentioned, and in systems which have not been studied, is very great.

We believe that investigation of these areas has great relevance for psychiatry. A variety of illnesses have been identified in which "psychological" factors may play a major role. These range from certain forms of allergy, hypertension, dermatoses, and disorders of the gastrointestinal tract, among others. For any processes which are so construed, social processes such as status, dominance, and role relationships and their complexities may be crucial parts of what has been considered "psychological". In the past, psychological processes in such illnesses have frequently been considered in terms of individual psychology rather than in terms of structural processes involving the individuals. In this paper we will deal exclusively with such structural explanations, although we are also convinced of the great importance of individual psychological processes.

We will present a general description of the concept of role and status, and then proceed to a more detailed description of status behavior in a variety

of human and nonhuman primate studies which suggest powerful evolutionary aspects of this behavior. Some of the literature relating status behaviors to endocrine function will be presented. Finally, we will consider aspects of the study of physiological sociology in terms of the relation of the physiological and behavioral events and the manner in which they may interact, and some of the possible relations of these materials to psychiatric illness.

Some General Aspects of Role Theory and Status in Human Groups

The oft referred to "group dynamics" insofar as they are repeated group to group, independent of particular persons, may be considered as structural in nature. Groups themselves may be voluntary or involuntary, formal or informal, open or closed. But, without a structure (patterned relationships), no aggregate of people may be considered a group. A reasonable level of organization of group behavior within which much of the physiological literature with which we will be concerned can be considered as roles. Briefly stated, the basic concepts used by role theorists include some of the following: Persons are the only actors in the social system and these persons occupy positions (statuses). To these positions are attached, to a greater or lesser degree, expectations for behavior. These expectations by self and others of rights and obligations associated with the positions constitute a role. Clearly, there is room for individual style in carrying out rights and obligations, and this is not part of the role. The position is delineated by shared expectations and the role is delineated by behaviors which reflect the positional expectations. (It should be noted that the position [status], as well as the way in which the role is enacted, may be evaluated by self or other, either positively or negatively. In this discussion, we will not be dealing with such evaluations; even though viewed as reward and punishment we believe they bear upon the central subject matter of this article.)

Relevant to role behavior are socialization into roles and maturational limitations on the abilities of actors to carry out roles. This area of development is of extraordinary importance and is essentially unexplored.

Any person carries about with him any number of role possibilities. Dependent upon the social situation, one or another may be activated. Each individual must be able to move from role to role, sometimes to juggle several simultaneously, and sometimes to find that role requirements are either ambiguous or in conflict with self-concept. Any and all of these can be termed role conflict; as such, for both literature and social psychology, as well as for psychiatry, they produce the stuff out of which the human drama is written.

Tension, its accompanying pains, and consequent psychological or social potential disruptions; inappropriate reduction mechanisms, again psychological or social in nature; and distortion of either self-concept or the social structure may result from role conflicts. It is not surprising that we may find physiological correlates to such powerful and ubiquitous human phenomena. Because of rapid social change, the roles for which children prepare, and the coping mechanisms which they have learned, may not meet the demands of their changing adult life situation.

Intrinsic to the idea of roles is the notion of reciprocity. For each status or position, there is a counter status; e.g., teacher-pupil; mother-child; friend-friend; employee-employer. Clearly, these may be hierarchically or horizontally arranged. Nevertheless, the rights and obligations which define the relationship are bidirectional, although not necessarily of equal intensity or frequency of emission. There are cases (probably most available to the therapist, and difficult to document as to validity) in which the reciprocal roles for the individual in question are purely symbolic, as is the actor to whom the role is attached. Thus, we may have images of absent figures influencing our actions. These figures are sometimes constructed from childhood experiences, fantasy, literature, or mythology. For sociological studies,

one would be concerned primarily with simultaneously present actors who simultaneously activate reciprocal roles.

A context within which to view notions of role is as a principle of organization which is meaningful to the individual actor (consciously or unconsciously), and to the observer. We may view culturally held norms becoming transmitted to the individual as attitudes, both general and specific. These attitudes become further organized around societal statuses or positions, and are emitted as behaviors. These behaviors could, of course, be viewed as packages of smaller acts.

Remembering that the individual is more than the sum of his statuses and roles, we nevertheless may claim that much social behavior, if not all, is partially governed by role considerations. The specifications for behavior are more or less rigid, vary in degrees of clarity. More frequently, individuals carry out their roles with a minimal amount of conflict and uncertainty. However, whenever a social situation activates two roles simultaneously, there is the possibility for conflict. In situations in which role requirements are highly specified, there is an increased possibility that required behaviors will be at odds with the individual's conception of himself, or even with higher order role commitments as perceived by the individual. Clearly, situations in which role requirements are not clear can be stressful. Equally clearly, there is great individual variation in both mode of dealing with, and degree of, felt stress involved in these situations.

Areas of inquiry which may be organized in terms of role considerations, although they may equally well stand alone, include power relations, coalition formation, leadership phenomenon, and affiliative bonding.

Ubiquity of Status

We are working from the point of view that man is a biological organism, similar in his biology to other organisms, especially that of other primates,

and that his biology is a determinant of the range of his behaviors, social as well as physical. His particularly human characteristics we take to be derived from the cortex: these include plasticity, use of experience, use of symbols and language, and time sense.

Rejecting "social Darwinism," we nonetheless believe that social structures and social processes which are found to be most widely distributed in small human groups will be found in other primates as well. Should this be true, one could project to underlying mechanisms, perhaps biological, which partially determine such processes (Barchas *et al.*, 1971). Casting our ideas in an evolutionary framework, we believe there is a substrate of social forms and processes, necessarily limited to small group interaction, which is common to the primates, including man (Barchas, 1970; Barchas, 1971; Barchas and Fisek, submitted; Darwin, 1896; McKinney *et al.*, 1971; Roe and Simpson, 1958). We tentatively agree with Colter Rule who suggests that some social behaviors, such as dominance "are as fundamental to human existence as such short rhythm phenomena as respiration and the heartbeat: intermediate (circadian) rhythms like sleeping, waking, eating, drinking; and longer rhythms like sexuality and seasonal changes"(Rule, 1967). We think it even more likely that some social processes involving structure are basic -- such as some status processes, affiliative bonding of several types, and some depressive reactions.

The ubiquity of status orderings in small groups has been repeatedly confirmed by observers of mammalian behavior (Alexander and Bowers, 1968; Altmann, 1962; Carpenter, 1964; Collias, 1953; DeVore, 1965; Hediger, 1964; Hinde and Rewell, 1962; Imanishi, 1957, 1960; Jay, 1968; Maroney *et al.*, 1957; Maslow, 1936; Portmann, 1961; Sadleir, 1970; Schreier *et al.*, 1965; Scott, 1945, 1958; Terry, 1970; Thompson, 1947; Tinbergen, 1955; Zuckerman, 1932). Whatever the nature of the population, status is generally thought

to influence such social behaviors as leadership, coalitions, aggression, priority of access to desired objects, intra-group conflict, conformity, and group structure (Carpenter, 1964; DeVore, 1965; Fisek and Ofshe, 1970; Jay, 1968). Given these relationships and the current proclivity to compare human with nonhuman behavior, and to seek animal models for studying human social phenomena, it seems reasonable to explore the status phenomenon in a variety of mammals so that methods and results can be comparable with results from human studies. This is particularly true if there continues to be an increased tendency among behavioral scientists to assume that basic social behaviors are in part biologically determined, and that the similarity in the biology of nonhuman organisms and humans may dictate similar social processes at the most basic level, although the specific social patterns and their meanings may rest on other foundations.

This view does not revive or take sides in the nature-nurture argument. It does, however, have evolution as its basic framework. It argues that the brain, like other organs, retains substrata, and that these substrata partially govern the most basic behaviors, such as learning, the capability for emotional behaviors such as depressive reactions, and some social interactions. While the effect of both further evolution and the impact of language and culture is not denied, this view does present the possibility that some of man's social responses are more adapted to past patterns of small group interaction, given the lag between culture and man's biologic adaptation (Hamburg, 1963). It also suggests that the most basic social responses may be studied in nonhuman populations with the same advantages and disadvantages as are found, for example, in the study of learning among nonhuman primates.

Approaches to Status and Findings in Humans

Status is, in general, an ordering of individuals by which rights, privileges, and responsibilities are distributed. The power and prestige order of a group is often considered synonymous with the status ordering (Berger *et al.*, 1966). Status is a ubiquitous phenomenon in human groups. Even gross knowledge of status positions explains and predicts many social behaviors (Berger *et al.*, 1966; Berger and Conner, 1969; Berger and Fisek, 1969; Fisek and Ofshe, 1970; Fisek, 1968). A description of a group typically uses status to order observations.

There are three aspects to the phenomenon of status emergence: status orderings form, are maintained, and change. We will review the literature dealing with status formation, omitting the portion dealing with maintenance and change. Most studies of status formation focus on *ad hoc* freely interacting task groups. (By task group, we mean any small group brought together for the purpose of achieving a mutual goal through mutual efforts.)

In this context, it has been found that diffuse status characteristics (such as age, sex, race), which individuals bring to the group, are likely to determine the status ordering with the group (Berger *et al.*, 1966). Recently, Fisek and Berger have presented material extending this approach to include any factor which discriminates among the actors, such as occupation, but not including personality and socialization variables (Berger and Fisek, 1974).

We note that in such groups, even when diffuse characteristics are held constant, a status ordering emerges (Berger *et al.*, 1966; Berger and Conner, 1969; Berger and Fisek, 1974). The Balesian tradition has yielded most of the data on such groups. The status order in freely

interacting task groups forms quickly, in as little as 45 minutes (Bales *et al.*, 1951; Bales, 1953; Bales and Slater, 1955; Berger *et al.*, 1966; Borgatta and Bales, 1953; Heinicke and Bales, 1953; Southwick *et al.*, 1961), and is stable. Working within this Balesian tradition, Fisek (1968) found that the differentiation occurred extremely rapidly.

Two routes to status formation have been studied, one in which the status order developes out of interaction, and one in which the status order precedes apparent interaction (Fisek, 1968). The work of Berger *et al.* may be taken as an exploration of the first route of formation, although it clearly deals with other matters as well (Berger *et al.*, 1966). In this approach, both formation and maintenance of the status or power and prestige order are systematically linked to the task through performance evaluations and consequent expectation states.

The Berger model does not account for those groups in which the differentiation has taken place prior to interaction, particularly those cases in which the observed initial order is stable over time. The simplest approach to explaining initially differentiated groups may be to look for variables which might operate in ways similar to diffuse status characteristics. Personality variables or socialization variables are often examples, both expressing themselves in "style", the cues for which could be extremely muted -- carriage, posture, propensity for eye contact. If one were to predict which individual was to occupy a given position, one would probably need to take into account such variables systematically. The results may be culture bound, and, in addition, depend not only upon the background of the actor, but upon the perceptions of the other actors.

Status as a process is especially suited to comparative study. As a phenomenon, status has received attention from sociologists of human behavior

for many years, and there is agreement that status is an important determinant of human behavior. A large body of descriptive, experimental, and theoretical literature has arisen concerning status. Those observations which have been made on established ongoing groups suggest that status differentiation occurs universally, and that status differentiations correlate highly with performance in a group.

Thus, status differentiation apparently occurs universally in human groups, and status can be observed in both ongoing and experimental groups. Further, when members of a group have a collective task, they evolve patterns of interaction which clearly reflect differences in power and prestige among the members of the group, even when they are strangers at the onset of observation and are matched for status characteristics.

Findings on Status in Nonhuman Primates

Similarly, observers of nonhuman mammals which live in groups have found some form of status differentiation to be generally present (Hebb and Thompson, 1954; Hediger, 1964; Hinde and Rewell, 1962; Scott, 1958; Simmel, 1950; Thompson, 1947). We restrict our comments in this section to nonhuman primates. Starting with Carpenter (1964), field observers have used the notion of status to order their observations. The term status has frequently meant dominance and has connoted priority of access.

Field workers and observers in semi-natural habitats have described aspects of group structure for many species, cataloging and describing behavior in context (Hall, 1968a, b; Imanishi, 1957, 1960; Jay, 1968; Kawai, 1958; Koford, 1965; Scott, 1964; Southwick, 1963). These studies generally have been done from a straight analogic approach or from an evolutionary approach to behavior, and it has been assumed that there may be common forms of social behavior across related species, if not common meaning for each

form. From these studies comes the suggestion that there are intriguing similarities in the organization of social behavior across primate species, the similarities becoming greater as higher levels of abstraction are used in behavioral categories.

Observational categories have been developed which are apparently reliable across observers. There has developed a concurrence regarding the "meaning" of some behaviors relative to slightly higher order concepts, such as dominance and deference. There is seldom a report in the primate literature in which some reference is not made to a dominance order, if not a status order, among the group.

In general, the high status animal has freedom of movement, other animals making way for the high status animal who may take the desired objects, such as food, from the other animals (DeVore, 1965; Jay, 1968). Data have been interpreted to mean that disruption of the status ordering causes instability in the group and that such variables as extent of group territory correlate with the temperament of the highest status individual in the group (Carpenter, 1964). One study (Dement, 1971) noted that the sleep of the high status animal was deeper and less disturbed than that of low status animals. It has been found that the later status position of an infant is influenced by the present status of the mother. Further, it is suggested that types of mothering are affected by the status of the mother. In general, it has been found that adult males have higher status than adult females who in turn have higher status than young animals, although there may be considerable overlap in these orderings (Champness, 1969; DeVore, 1965; Jay, 1968).

Most observations of nonhuman primate groups have been made on single groups of mixed age and sex. There is consensus among observers that status relationships partially order behavior. It has generally been assumed that

these relationships are the product of long-term socialization in stable groups, and that the advent of status relations developing in new groups can be attributed to external differentiating characteristics in the animals, such as sex, size, and weight. Goodall and Hamburg suggest, on the basis of observations of free-ranging chimpanzees, that motivation and "technical ingenuity" may be factors in an individual's rise in dominance.

Status differentiation has been found to be stable in naturally occurring groups, although there are clearly conditions under which status shifts occur, these being related to growth and development as well as to cyclical and other biological changes. Bernstein and Mason, reporting on a newly-established mixed group, state that status relationships formed within the first hour of interaction were stable for 75 subsequent days (Bernstein and Mason, 1963).

Focusing upon the dominance aspect of status in groups of mixed status, Bernstein and Mason have demonstrated that dominance relations in mixed groups were quickly formed. Miller and Murphy (1956) report that such relations are stable, and Warren and Maroney (1958) and Kawai (1958) have demonstrated them to be highly resistant to change. These features have been attributed to (1) external status differences, or (2) long-term socialization of the individuals with each other. However, in a study by Barchas (1971), these two attributions were ruled out as both were controlled for. Thus, animals with fully developed social repertoires have the capacity to form status orderings out of interaction which is independent of broad differentiating cues and of interaction with known individuals.

In mixed groups, the fully adult male is dominant over females and younger animals, the larger animal over the small; the animal in good condition over the the animal in poor condition. Most observations are upon groups of varying statuses.

Clearly, both human and nonhuman primates in field and laboratory settings have been observed to exhibit status orderings.†

† As has been stated, in humans the basic finding about status orders comes from Bales and his associates, " ... marked inequalities develop over time in the rate at which members are observed to initiate interaction ... (and) those who initiate action most frequently tend to be ranked highest on the criteria of 'best ideas' guidance and tend to receive actions from others at the highest rate." This occurrence has been further documented in a variety of different contexts and its stability established with little question (Bales *et al.*, 1951; Bales, 1953; Bales and Slater, 1955; Borgatta and Bales, 1953; Fisek and Ofshe, 1970; Heinicke and Bales, 1953; Stephan and Mishler, 1952). For specific information on contexts other than the original Bales study, see Berger *et al.*, 1966. (Investigation into the phenomenon as a process and on a theoretical and experimental level has been most vigorously pursued by a group of Stanford sociologists (Berger *et al.*, 1966; Berger *et al.*, 1974).

SOME ENDOCRINE CORRELATES OF STATUS RELATED BEHAVIORS

Adrenal Cortical Function

Until recently, the relationship between status and endocrine function has been investigated primarily in rodents (Conner, 1972). Such studies have tended to focus on the relationship of adrenal cortical function to dominance (one dimension of status), and have yielded fairly consistent results. Thus, the studies of Barnett (1955) regarding fighting behavior in wild rats suggested, in a dramatic fashion, that the adrenal cortical hormones may be markedly depleted following fighting in the subordinate animal, but not in the dominal animal, although both appeared to have had an equal overt stress. In a study of male mice derived from a wild strain, it was noted that there was an inverse correlation of the adrenal weight and social rank in animals having had social interaction over a ten day period; high ranking animals have smaller adrenals than do low ranking mice (Davis and Christian, 1957). Such findings may be related to physiological changes occurring in crowded conditions, where it has been found that in rodents, increased group density results in increased adrenal weight, but decreased body and testicular weights (Christian, 1955; Thiessen and Rodgers, 1961). Isolated male mice display lower resting levels of plasma corticosterone and a decreased response to stress (Brain and Nowell, 1971). If mice are maintained in a paired situation for several weeks, the subordinate mice are characterized by higher adrenal weights and lower gonadal weights; however, if tested in a single trail against a new nonaggressive antagonist, the subordinate animals behave with the same range of behaviors as the dominant animals (Brain, 1972). The author notes that it is not surprising that the later behavior is independent of the earlier behavior since the behavior is part

of an established hierarchical response and the response to an unfamiliar individual should be independent.

Direct measures of adrenal activity by measurement of plasma corticosterone as an indicator of adrenal cortical activity have been obtained (Louch and Higginbotham, 1967) which confirmed the earlier impressions based upon adrenal weight; dominant mice had significantly lower levels of corticosterone than subordinate animals. The causal nature of the relationship has not been established.

Primate studies have provided a quite different view. Although such studies are difficult, the work of Leshner and Candland (1972) is particularly interesting in the suggestion that higher status is associated with increased adrenal cortical activity. Their work utilized assay of urinary 17-hydroxycorticosteroids with correlation to dominance ranking in an ongoing group of squirrel monkeys. Such a view is confirmed, through adrenal weight measures, though regretably without kinetic endocrine measures, in work with crab-eating monkeys (Hayama, 1966).

Another group of investigators (Levine *et al.*, 1970) have obtained data relevant to the issue by determining the relation of aggressive behavior in rhesus monkeys to 17-hydroxycorticosteroid output in a stress situation. It was found that the animals which were considered to be more aggressive by the testing procedures used had a higher steroid output in response to a stress, were dominant in certain testing situations, and learned a task more slowly. The learning difference seemed to result from the agitated and combative response of the dominant animals to a situation in which they received shocks as compared with a much quieter pattern in the nondominant animals.

An interesting but difficult investigation to interpret in light of the preceding studies dealing with primates, comes from the work of Sassenrath (1970) who studied the response in rhesus to adrenocorticotropic hormone (ACTH) on urinary steroids collected outside of the behavioral situation. In that study, the dominant animal has the lowest secretion of 17-hydroxycorticosteroids in response to ACTH. The interpretation would be that the response to ACTH is a test of the adrenal size, and that the lower the response, the less the activity of the adrenal. Thus, the results would appear to contradict those cited earlier. In these studies, there was a decrease in the ACTH response by any activity, such as transfer to individual caging, or removal of the dominant male. Although the interpretation is complicated, the results suggest powerful influences of social behavior on pituitary-adrenal function.

If one accepts the Leshner and Candland (1972), and Hayama (1966) data, there are profound differences between the rodent and primate in regard to pituitary-adrenal function for which the reasons are unclear. The differences are viewed by Leshner and Candland as due to the different styles of ongoing interaction. Thus, in the rodent, dominance is established by direct physical attack, while in the primates that have been studied the dominance is settled by ritualized displays. These processes may relate to varying forms of aggressive interaction which have differing underlying endocrine and neurochemical mechanisms (see Goldstein *et al.*, in press).

Studies dealing with endocrine measures in primates are difficult because of the problems associated with obtaining adequate or appropriate samples of blood in relation to ongoing behaviors. Thus, freqently the

collection of the compound of interest is accomplished under conditions which are different than those involved in the status situation or social behavior situation *per se*. One could anticipate that for some behaviors, there may be marked differences between the social situation and the collection situation in terms of endocrine response.

Gonadal Function in Males

Only very recently have procedures been developed which enable direct investigation of testosterone in relation to social behavior. Not only have the chemical assays required development, but the behavioral procedures for collection of blood samples have also required development, so as to be able to obtain the samples very quickly in adapted animals. As a consequence of such development, important studies in which the behaviors could be determined with good reliability in relation to the endocrine measure have become possible (Rose *et al.*, 1971; Rose *et al.*, 1972). From the studies involving 34 animals in a one-third acre compound, it was established that dominance rank was positively correlated with testosterone concentration. The animals in the highest quartile had significantly lower levels of testosterone than those in the lower quartile, although there were no significant differences between animals in the second, third, or fourth quartiles. Aggression also correlated with testosterone, but the correlation of high submissiveness and low testosterone was not high. The complexity of the data is shown in the fact that the relationships are not always simply related. Thus, the most aggressive animals are not always the most dominant, and the most dominant animal need not have the highest testosterone. The studies led the investigators to a series of investigations of the relationship of the behaviors

to the endocrine changes, and to determine whether testosterone changes were preceded by changes in dominance. The data to investigate this possibility was obtained using smaller groups and allowing animals to take a dominant position, in which case plasma testosterone increased; if the dominance position sharply decreased, the plasma testosterone decreased. These results are also of interest in light of the findings that plasma testosterone in humans is decreased by stress (Kreuz *et al.*, 1972).

Adrenal Medullary Function

Relations of adrenal medullary secretion to behavioral processes related to social behavior has proceeded upon two fronts. The first has been the area of measurement of adrenal medullary hormones, epinephrine (adrenaline), and norepinephrine (noradrenaline), generally utilizing urinary samples. The second, in animals, has involved studies of the enzymes which form the catecholamines in the adrenal, as well as measurement of the catecholamines, with determination of changes associated with behavioral states. The rapid changes which can occur in the adrenal medullary system and the powerful psychological effects of epinephrine (Mason, 1968; Barchas *et al.*, 1971) makes this system a particularly interesting one for investigation.

Several studies suggest that social behaviors may alter the enzymatic processes involved in the formation of the catecholamines. Among those areas of investigation are studies dealing with social isolation and group housing, as exemplified by the studies of Welch and Welch (1968), who found decreased levels of catecholamines in the brains and adrenal of group housed mice when contrasted with individually housed animals. Although the results of such studies may depend upon the species used (Stolk *et al.*, in press), it is

clear that differential housing can markedly alter catecholamine mechanisms. More directly related to social interaction have been the investigations represented by the collaboration of Henry and Axelrod and their colleagues (Henry *et al.*, 1971; Henry *et al.*, 1972), who have utilized a variety of mutual interaction situations including interconnected cages, a technique which leads to confrontations and severe social stimulation. In animals exposed to such severe social interaction, there were increases in the enzymes which form catecholamines in the adrenal, as well as increases in the levels of the hormones themselves. A decrease in the enzymes was noted in isolated animals. Preliminary studies have suggested that dominant animals may have lower levels of the enzymes which form catecholamines than the subordinate animals have. Many of the studies of the investigators utilized long-time bases (in some of the studies, periods as long as six months were used), and it will be of interest to see if changes associated with these and other social interaction paradigms can be demonstrated with short-time span interactions. Rapid changes in the enzymes which form catecholamines have been noted (Ciaranello *et al.*, 1972a) occurring within a few hours of certain forms of stress, which suggests the possibility of investigations involving behavioral states with short-time parameters in the appropriate social situation.

Studies of adrenal medullary function in humans have concentrated on determination of epinephrine and norepinephrine in urine. This has been necessary because of the difficulty of measurement of the catecholamines in blood samples because of limitations of current assay procedures. Thus, samples which are assayed represent a pooling of many time dependent processes, usually over a period of several hours, which is unfortunate, yet

makes the fact that there are positive results even more tempting for future analysis with multiple time points. Ultimately, one would expect that assessment of adrenal medullary function in humans would involve determinations at close time intervals by means of new techniques which are now being developed, such as mass fragmentography (DoAmaral and Barchas, in press).

Several investigators have demonstrated powerful effects of psychosocial interaction variables on adrenal medullary secretion. Many of the studies have demonstrated that a variety of behavioral situations which involve tense, anxious, but passive emotional displays, are associated with elevated epinephrine output (Elmadjian *et al.*, 1957), as can certain novel or distressing situations (Tolson *et al.*, 1965). A variety of psychological states have been investigated in a pioneering series of studies conducted over many years by Levi (1972) and brought together in a recent monograph. Urinary catecholamines were found to increase in a wide variety of arousing situations, such as viewing films with both "pleasant" and "unpleasant" aspects as considered by the subjects. Bland materials reduced the levels of excretion. Psychosocial stimuli were found to alter catecholamine secretion, depending upon the stimuli and on the starting point of the organism, without any simple relationships between anxiety and epinephrine secretion or aggression and norepinephrine secretion.

Frankenhaeuser (see review, 1971) has conducted a series of careful investigations relating cognitive and emotional patterns with endocrine secretion. Among the most interesting studies has been a series of investigations in children (Frankenhaeuser and Johansson, 1971), which, while not specifically concerned with status, suggest powerful social inter-

relationships which may bear on status and power relationships. For example, there was a positive correlation between the norepinephrine secretion between mother and son, but not between father and son. There appeared to be a significant positive correlation between the mother's adrenaline output and the frequency at which the fathers punished their children. Such studies of interactional and developmental processes, particularly when combined with social processes, suggest outlines for the development of a new research area.

A means of studying the relationship of social processes to endocrine processes has emerged from investigations of the relationships of free fatty acids to social behavioral states. Free fatty acid levels are believed to correlate highly with sympathetic activation of which adrenal medullary activity would be an important component. In a series of studies characterized by the use of rigorous behavioral parameters, as well as rigorous chemical measures, Back and Bogdonoff (see review, 1964) have demonstrated correlations between chemical measures and behavioral measures of conformity and leadership in test situations in which these parameters could be directly controlled. Using changes in free fatty acids as an indicator, the authors of these pioneering studies note that "...if the social situation is perceived simply as a background to individual achievement, the dominant variable will be the potential for individual achievement and its meaning. In this situation, pressure to conform and pressure to assume leadership may be viewed as arousing stimuli, and the individual may seek to avoid these situations. If, however, the group relationship has the dominant meaning, the performance of the task may be seen in terms of the group interaction, and then deviation from the group norm becomes

the arousing condition. Conforming behavior is then attended by decreased arousal." [pg. 41, Back and Bogdonoff, 1964]

A direct study of the relationship between social status processes and catecholamine secretion has just been completed (Barchas and Barchas, in preparation). In that study, individuals were brought together who were of equal external status (education, age, race, sex) and who interacted for a one hour period. The status differential which was established between the individuals through interaction was assessed by observers and by questionnaires to the subjects. Urinary catecholamines (epinephrine, norepinephrine, and dopamine) were obtained before and after the session. There was no relationship between the urinary catechols taken before the interaction and the acquired status, but there was a pattern of association between acquired status and the urinary catechols sampled after interaction.

Brain Serotonin

Biogenic amines in the brain have been studied in terms of their relation to several behaviors, including severe psychiatric disorders (as reviewed in various ways in several chapters in this volume). Serotonin, an indoleamine, has been postulated to act as a regulator of neuronal function as a possible transmitter (Barchas and Usdin, 1973). The compound has been linked to specific forms of behavior, but only limited studies related to social behavior have been conducted. A major procedure for investigating the effects of changes in brain serotonin involves use of *para*chlorophenylalanine (PCPA) which inhibits the formation of serotonin although it may also act on other chemical systems. Studies in which PCPA has been administered to primates have been very few and suggest decreased activity. Boelkins (1973) administered the drug to an ongoing group of

three crab eating macaques (*Macaca fascicularis*) and observed that the number of social behaviors decreased, but that the time spent in social huddling increased, with no change in aggressive or other behaviors.

Maas *et al.* (1973) in studies with two groups of *Macaca speciosa* observed no changes in aggressive or submissive gestures, attacks, or hetero- and auto-grooming.

In each of these studies, the degree to which brain serotonin mechanisms have been interfered with is open to question, and larger doses of the inhibitor of serotonin formation cause the animals to appear ill, possibly due to peripheral effects. Thus, the role of serotonin in primate social behaviors is deserving of further investigation.

Brain Catecholamines

Particular attention has focused on catecholamines as they relate to a variety of behaviors (Barchas *et al.*, 1972). By the use of specific inhibitors of the formation of catecholamines, studies have been performed suggesting important roles for catecholamines in social behavior. In a series of papers, the group associated with Maas (Redmond *et al.*, 1971a,b; Maas *et al.*, 1973; Redmond *et al.*, 1973) have investigated such processes in studies with macaque monkeys. In one set of investigations, the drug α-methyltyrosine, an inhibitor in the first step of catecholamine synthesis, was administered to some of the animals in a group living situation, with monitoring of the social behavior. It was found that the animals had a marked decrease in social initiation of behavior, including grooming, threats and attack, although they responded to other animals. There also may be dominance shifts; an animal who was dominant did not have a change in social dominance, while two other animals had a decrease in dominance.

In another study, a different drug, 6-hydroxydopamine, which destroys many of the neurons which contain norepinephrine in the central nervous system, was administered to free-ranging macaques. The treated animals were more peripheral to their social group, exhibited decreased social behaviors, initiated fewer threats, less social grooming, and fewer social initiatives than the control animals.

The results of the Maas group demonstrate powerful effects of central catecholamines in social processes in nonhuman primates. Such studies would suggest that certain forms of social behaviors may be mediated by catecholamine-containing neurons and be altered by drugs which alter catecholamine mechanisms. The processes which have been studied are related to very basic social processes which have previously been shown to be related in similar ways in nonhuman and human primates (Barchas and Fisek, submitted). The findings that central catecholamine systems are profoundly involved in primate social behaviors raises questions as to the role of catechols in humans.

PSYCHIATRIC PROCESSES AND PHYSIOLOGICAL SOCIOLOGY

Some Aspects of Sociopathic Behavior - as an Example

There are a number of psychiatric processes in which there is clinical reason to believe that there are profound disturbances of sociological processes, including status, dominance relations, and affiliative bonding. One psychiatric illness which manifests itself in social structural relationships in a profound was is sociopathic behavior.

By the very nature of the sociopathic individual, persons with the disorder display altered social behavior (Robins, 1966). The question as to whether such individuals respond differentially when compared to normals, in terms of their physiological responses, has been raised by several investigators, with some evidence suggesting that there are such differences.

Among the factors which have been investigated have been learning variables in which the studies of Hare and others have suggested that classical conditioning of autonomic responses and avoidance learning may be impaired (see review of Hare, 1970). For example, it has been found that psychopathic criminals acquire conditioned electrodermal responses more slowly, that the formed responses are of lesser magnitude and are more quickly extinguished, and that once acquired, the responses are generalized to a lesser degree than in nonpsychopathic criminals. These studies and others have been summarized to suggest that psychopaths may have normal attention to stimuli, but a decreased anticipatory fear (Hare and Quinn, 1971).

From the standpoint of this review, particularly relevant are a series

of provocative studies dealing with the response to an injection of adrenaline by psychopaths when compared to varying other populations. The literature has been quite contradictory, but does strongly suggest that there are differences (Schachter and Latané, 1964; Goldman *et al.*, 1971; Hare, 1972). The various experiments were performed under different conditions, including degree of ongoing activation. In the studies of Hare, which were able to take advantage of the earlier findings and to work with a carefully selected population, it was found that the change in skin conductance following the injection of adrenaline was smaller in a psychopathic group compared to a criminal nonpsychopathic group. In that study, differences in heart rate which had been noted in the earlier studies, with quite different subject selection procedures and activities, were not found. Questions as to the hyper- or hyposensitivity of aspects of the autonomic nervous system have been raised by the various studies, although conclusions would require considerably more investigation.

Another side of the coin remains to be investigated -- the effects of stresses on direct endocrine release. Such studies would involve, for example, in relation to the previous literature, determination of release of epinephrine and norepinephrine and the enzyme which converts dopamine to norepinephrine (dopamine-β-hydroxylase), which can be measured in the peripheral blood. Ideally, diurnal rhythms and the response to stress, and particularly the response to emotional conditioning, would be obtained. Studies of central brain mechanisms are clearly indicated.

The literature dealing with psychopathic behavior raises the question as to whether this form of social behavior, which involves a psychiatric diagnosis, may not involve powerful biological aspects. One could imagine

either biochemical differences based on genetic factors or such differences based upon early experience. In either event, it is strongly possible that psychopathic illness may reflect interactions between social behavior and biochemical processes.†

Frequently role enactment requires simultaneous action or interwoven action between two or more individuals. Discrepancies in perceptions of roles may lead to group stresses. Most frequently, in this situation, there is a mutual adjustment of expectations. When there is not, we may have emerging such phenomenon as schism and skew in the family and scapegoating (here seen as a mode of releasing group tensions regarding roles to the detriment of the individuals involved). Similarly, the phenomenon of the double bind seen from the points of view of the sender and receiver of messages may be partially visualized as inadequate internalizations and expressions of role relations. Such social behaviors could be expected to have profound effects on the types of parameters considered in this chapter. An additional example of the application of role theory and status processes to psychiatric illness could be made in the case of depressive illness.

Toward a Physiological Sociology

It is difficult at this early point in the development of physiological sociology to give an adequate general formulation of the potential relations between biochemistry and sociological behaviors. At this stage, it seems reasonable to assume that biochemical and sociological processes are

† The reader is referred to Leiderman and Shapiro (1964) for a collection of experiments which bear on the general subject.

intimately related. Biochemical processes may affect, for example, activity levels, emotional tones, and the susceptibility to stress. Sociological processes may set in motion processes which influence biochemical mechanisms; for example, by changing the levels of particular compounds by producing shifts between pathways, altering utilization of compounds, and inducing enzymatic changes. Biochemical events may profoundly alter the ability of the organism to respond to its environment.

If one visualizes a relationship between biochemical and social structural events and assumes changes in response to a sociological event, then such changes become very important in relation to the length of time that they persist and the manner in which environmental and genetic factors interrelate. To account for long-term emotional behaviors and alterability of behaviors, one would have to assume alterability in underlying chemical events. In the simplest model, we would assume that sociological events affect the body chemistry and that the chemical change in turn affects the future sociological events. Thus, with particular genetic predispositions, chemical changes that are long-term in nature could, in effect, "lock in" certain psychological sets.

Different genetic strains have already been demonstrated to have a considerable variation in terms of the steroid hormones produced by the adrenal cortex (Hamburg, 1967, 1970; Hamburg and Kessler, 1967) and thyroid hormones (Hamburg and Lunde, 1967). A number of illnesses have been

demonstrated in which there is a genetic difference in formation of adrenal cortical hormones; several of these illnesses lead to marked behavior change.

There is now strong evidence to suggest that some of the other biochemical systems that we have been concerned with in this chapter are also under genetic control. Thus, the levels of the enzymes which synthesize catecholamines (epinephrine, norepinephrine, and dopamine) vary in different inbred strains. The degree to which the level of the enzymes can be altered by stress and even the types of stresses to which there are responses varies in different inbred strains (Ciaranello *et al.*, 1972a,b,c; Kessler *et al.*, 1972; Barchas *et al.*, in press, a & b; Hamburg *et al.*, in press; Milkovic *et al.*, in press.).

An extensive listing could be made of how possible genetic differences in a system such as that involved in catecholamine production or utilization, both in the adrenal or in the brain, might affect behavior. It has been shown that in response to stress, differing amounts of adrenal cortical steroids are released in different genetic strains. It is easy to imagine that in response to stress, two individuals might send the same number of nerve impulses to the adrenal medulla, but because of a genetic difference, one individual might form differential amounts of catechols, release differential amounts, metabolize the catechols at different rates, or have differential passage across the blood-brain barrier. If any of these possibilities were to occur, clearly, there could be behavioral changes when the adrenaline reached various target organs, including the brain.

Other possibilities to be investigated include the presence of minor or abnormal pathways in adrenal catechol metabolism, including the

physiological controls on those pathways and how they might be altered by social stress. Analogous factors could be relevant not only to adrenal catecholamines as hormones related to behavior, but also to brain catecholamines and other putative transmitters between nerve cells.

The hormonal systems have been related by physiologists to stress responses and it has been repeatedly suggested that feelings which accompany changes in levels of these hormones are interpreted by the individual according to past learning and present situational cues (Schacter and Singer, 1962; Schacter and Wheeler, 1962). Using the conceptual framework of role theory, we may then direct our attention to those points at which stress may be expected and which may be the places where pattern correlation (within a culture) are most likely to be seen between physiology and behavior. Conceptualization of these points should be at a level which cuts across specific roles. In addition to points of stress, there are expected to be physiological relationships to the building blocks of roles such as dominance or deference relations, and affiliative bonding.

For any given individual, the relationship of physiological response to particular role stress events may be posited as highly predictable. It would seem reasonable, however, when characterizing a population with regard to the relationships of physiology to role stress to think in terms of more general categories. Also, for some individuals, stress repeatedly occurs with interaction in a nurturance system.

The idea of causality in the relations between endocrine and sociological events may be and has been helpful practically as experiments are set up and run. For some purposes, that notion of causality is heuristically facilitated. However, if we are indeed dealing with a homeostatic system

in terms of the individual's physiological system as it adjusts to the psychological and social environment, then over-emphasis on causality may, in the broad picture, obscure our vision. But it is not difficult to utilize those conditions on the one hand, while on the other we work toward a more intuitively satisfying understanding of how the individual makes his peace with his world, both physiologically and sociologically.

It is clear that more information relative to the issue of the manner in which sociological events interact with biochemical variables will be needed. How do developmental patterns and behavioral states such as status orders or affiliation influence biochemistry? Can the response of endocrine agents or brain neurotransmitter agents to situations later in life be altered by early experience? What types of changes in the various mechanisms involving neuroregulatory agents can be found in different sociological states? What are the short- and long-term biochemical effects of different types of sociological situations? Does biochemical state influence social behavior? What is the possibility that behavior, such as repeated dominant or submissive behavior, may alter the propensity for long-term or repeated episodes of the behavior? Such studies involve animal investigation, but may lead to human studies. For example, to what extent does a sociological event, e.g., high status or low status, trigger biochemical changes which affect later events, thereby causing a cycle of actions which is neither wholly "sociological" or "psychological", nor wholly "biochemical".

From the standpoint of psychiatry, one might well imagine that there will be psychiatric illnesses which will meet the model of phenylketonuria in which a set of clear-cut definable biochemical changes lead to severe

behavioral changes. Understanding why "those" behavioral changes occur will be a crucial step. On the other hand, there may be other emotional illnesses which are more purely social structural or psychological than in the model just mentioned and there may be still other illnesses in which a set of social interaction events or psychological events in an individual with appropriate biochemical structures lead to an illness.

On the one hand, one encounters those who view mental illness and mind as apart from the brain, and, on the other, those who feel that a twisted thought, a twisted molecule. What is needed is a view which recognizes the subtle interplay of sociological, individual psychological, biochemical, and physiological processes.

Recent research, including some presented in this paper, suggests the development of a new field of physiological sociology. Such a term is analogous to physiological psychology, and yet recognizes the new approaches and techniques which will be necessary for the field and its concern with behaviors related to group structure and processes. The area is exciting in its conception, and yet poses many problems from technical to philosophical. Some of the problems include issues of delineation of relation of biochemical events to sociological strutured events, the action of drugs on social structure, and developmental processes.

SUMMARY

We have chosen to examine some of the endocrine correlates associated with status behaviors because status behaviors can be viewed as one of the most basic building blocks of structural social relations. Status structures are commonly found throughout mammalian species, status behaviors have been sufficiently studied, and theories have been constructed, so that it is possible to begin to perform physiological investigations. Studies to date, although few in number with higher primates, suggest the potential of important correlations in a number of endocrine systems, with potential consideration of genetic and developmental processes. Such information can be of importance theoretically in terms of understanding aspects of the behavior, and potentially in altering some forms of behavior that may be deleterious for the individual. Further, such information may aid in understanding somatic processes in terms of aspects of social structure that profoundly alter somatic function. Such information may prove of value not only in theory, but also, potentially, in treatment of psychiatric and psychosomatic conditions, which would be a particularly important aspect of the new field of physiological sociology.

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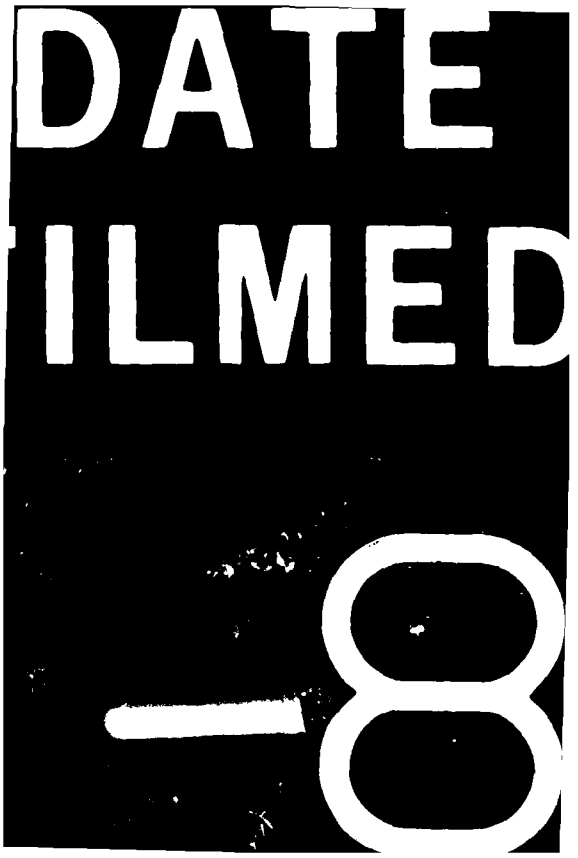
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